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Treatment of Waste Water from Natural Rubber Processing Plant

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Abstract: ***Rubber industry is an economically and socially significant industry. It consumes large volumes of water, uses many chemicals and produces enormous amount of effluent. It is later discharged into the water ways and causes pollution that affects human health. For solving the above problem, three bacterias were identified and isolated from rubber processing industry effluent - Arthrobacter sp, Pseudomonas sp and Bacillus sp. The selected bacterias were tested for its efficiency on the bioremediation of rubber processing industry effluent, individually and as a consortium. Reduction in the physicochemical properties of the effluent such as TS, BOD, COD and ammonia were observed after 15 days of incubation. Based on the data obtained in this study, it can be concluded that biomass of this bacterium can be used for bioremediation of rubber processing industry effluent with high efficiency.***

Keywords: Bioremediation, Rubber processing industry, waste management, latex effluent treatment, Biological treatment, Rubber latex

1. Introduction

Natural rubber is a versatile industrial raw material derived from the rubber tree Hevea brasiliensis. It is a high molecular weight polymer with visco-elastic properties. Latex is an economic produce harvested by controlled wounding on the bark of the tree, known as tapping. The latex contains 40% natural rubber and remaining water and other constituents. Natural rubber has applications in tyre, footwear and engineering related industries. Nearly 65% of natural rubber is consumed by automobile industry. Natural rubber is the main component in heavy duty tyres. Besides, it is used for manufacture of bicycle tyres and tubes, hoses, conveyor belts, foam mattresses, footwear, balloons, toys and several other products of daily use. It also has engineering applications in shock absorption, vibration isolation and road surfacing. It is often vulcanized by adding suitable vulcanizing agents to provide better tensile strength and to improve properties like abrasion resistance.

Since the production of rubber products from natural rubber needs large amount of water for its operation, the rapid growth of rubber industries has produced large quantities of effluent from this processing [2][4]. The effluent includes wash water, small amounts of uncoagulated latex and serum with small quantities of proteins, carbohydrates, lipids, carotenoids and salts.

Wastewater discharged from latex rubber processing usually contains high level of BOD, COD and SS. These characteristics may vary from country to country due to difference in raw latex and applied technique in process. The main source of pollutants is the coagulated serum, field latex coagulation and skim latex coagulation. These compounds are readily biodgradable and will result in high oxygen consumption upon discharge of wastewater in receiving surface water. The effluent is also acidic in nature. Different extends of acid usage in different factories attribute to pH variation of different effluent. A serious threat of rubber wastewater is high concentration of ammonia in this effluent. It contributes to undesirable eutrophication [3]. Without proper treatment, the discharge of wastewater from rubber processing industry to the environment may cause serious and prolong consequences. Therefore, suitable technologies must be used for treating this wastewater [6].

Many methods, including physicochemical and biological treatments, have been studied for the effective treatment of rubber processing waste. Most of these methods are not cost-effective and does not remove all the contaminants. Hence the use of biological methods for treatment is of greater importance nowadays. Bioremediation is a popular and attractive technology that uses the metabolic potential of microorganisms to clean up the environment [5]. Owing to the need of biological treatment of rubber industry wastes and knowing the fact that various bacteria can grow and degrade the rubber industry waste [1]. The present study was carried out to compare the efficiency of Pseudomonas sp, Bacillus sp, Arthrobacter sp and bacterial consortium consisting of these three bacteria.

2. Materials and Methods

2.1 Sample collection

The sample for initial characteristic study was collected from V C Thomas and Company, Industrial Development Area, Kochuveli, Trivandrum. The sample was collected in sterile plastic containers, rinsed several times with the sample and maintained at 4^0C for further studies. The effluent sample used for DO determination was taken directly into dark DO bottles and added few drops of manganous sulphate solution to fix the dissolved oxygen. The sample was analysed for its characteristics and its results is shown in table 3.

2.2 Bacterial culture preparation

The bacterial cultures selected for bioremediation were Arthrobacter sp, Pseudomonas sp and Bacillus sp. The genres have been effectively used for bioremediation in many fields. The Arthrobacter sp bought from Microbial Culture Centre (MCC), Pune was sub-cultured on nutrient broth. Pseudomonas sp and Bacillus sp has been prepared in CET microbiology lab. The composition of the broth is given in table 1. It was prepared by mixing the components in 50 mL distilled water. The inoculated broth was then placed in the incubator for 24 hrs and then stored in refrigerator under optimum conditions.

Table 1: Nutrient broth composition

Composition	*Quantity (g/L)*
Peptone	5
Beef extract	3

Optical density of the inoculum was measured using a double beam UV-VIS spectrophotometry at an absorbance of 610 nm.

2.3 Acclimatization of the culture

The acclimatization of bacteria was done by growing it in minimal organic salt medium amendsed with 10% of the rubber processing effluent. Composition of the minimal organic salt medium is given in table 2.

Table 2: Composition of minimal organic salt medium

Composition	*Quantity*
KH_2PO_4	0.675 mg/L
Na_2HPO_4	5.455 mg/L
NH_4Cl	0.25 mg/L
$MgSO_4$	0.2 mg/L
$Ca(NO_3)_2$	0.1 mg/L

2.4 Experimental setup

Reactors of 3 L capacity each were used for this study. The reactors made of acrylic are of dimension 10 cm X 10 cm X 50 cm. Reactors were washed with alcohol to make it sterile and then rinsed with sterile distilled water. The wastewater and 10 mL of each microbial culture was introduced into the reactors and top portion of the reactors were covered with aluminium foil paper. The aerator was used to maintain desired level of dissolved oxygen in the effluent so as to support the proper growth and survival of aerobic microorganisms used for the study. The treated effluents from the reactors are taken at an interval of three days and were tested for various physico-chemical parameters in laboratory.

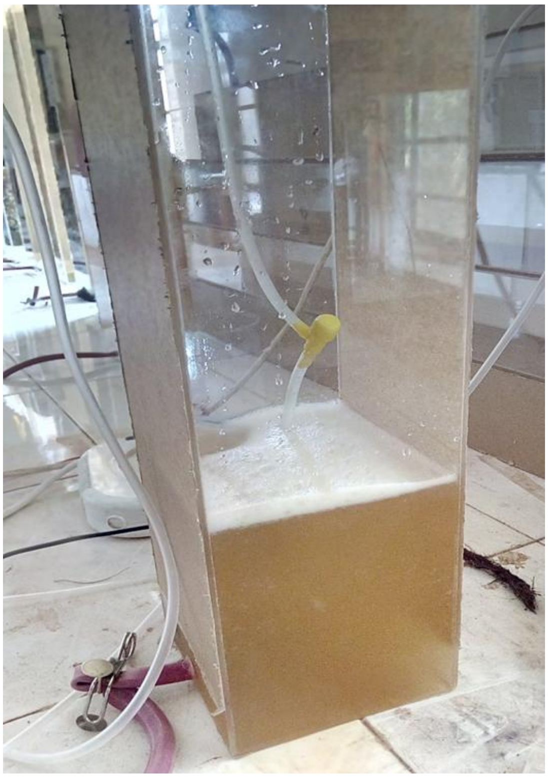

Figure 1: Experimental Setup

2.5 Confirmation of biodegradation

Physico-chemical characteristics such as biochemical oxygen demand (BOD), chemical oxygen demand (COD), total solids (TS) and ammonia (NH_4^+) were analysed using standard methods (APHA, 1995). The effluent was inoculated with 10 mL inoculum and aerated for 15 days, and estimation was done at an interval of 3 days.

3. Results and Discussion

The results obtained from the initial physico-chemical analysis of effluent are shown in table 3.

Table 3: Characterization of effluent before treatment

Parameter	*Permissible limit*	*Value obtained*
pH	6-8	4.5
BOD (mg/L)	50	4000
COD (mg/L)	250	7000
TS	2100	9500
Ammonia	50	99

3.1 Optical density

Optical density of the prepared bacterial medium found using spectrophotometer are shown in table 4.

Table 4: Optical density values of bacteria

Bacteria	*Optical Density*
Arthrobacter sp.	1.41
Bacillus sp.	1.90
Pseudomonas sp.	2.17

3.2 Characteristics of effluent after treatment

3.2.1 pH

The pH of the untreated sample was acidic. After treatment with microbial isolates, it was observed to be alkaline in nature. The pH of the effluent treated using Arthrobacter sp varies from 4.5 to 8.3 and the values obtained using Pseudomonas sp, Bacillus sp and bacterial consortium were 8.1, 8.5 and 8.7 respectively. The comparisons of pH after treatment using different bacteria are shown in Figure 2.

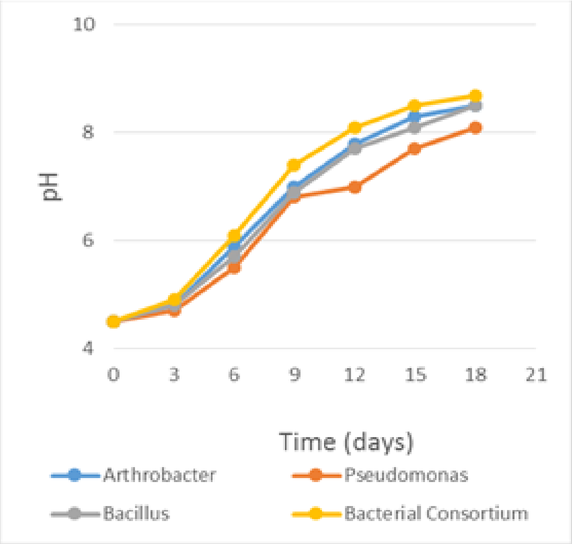

Figure 2: Comparison of pH after treatment

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Table 5: Characteristics of effluent after treatment using Pseudomonas sp.

Time (days)	*pH*	*Total Solids (mg/L)*	*BOD (mg/L)*	*COD (mg/L)*	*Ammonia (mg/L)*
0	4.5	9700	4300	7600	99
3	4.7	9450	4050	7210	74
6	5.5	8700	3800	6500	63
9	6.8	6400	2900	4700	42
12	7.0	4000	1900	2550	30
15	7.7	2600	1600	1950	26

3.2.2 Total solids

The reduction in total solids of rubber effluent after treatment is shown Figure 3. Reduction efficiency of Arthrobacter sp, Pseudomonas sp, Bacillus sp and bacterial consortium were 77.31%, 73.19%, 72.68% and 79.38% respectively. The reduction of TS after treatment might be due to use of suspended organics by microorganisms for their growth and development.

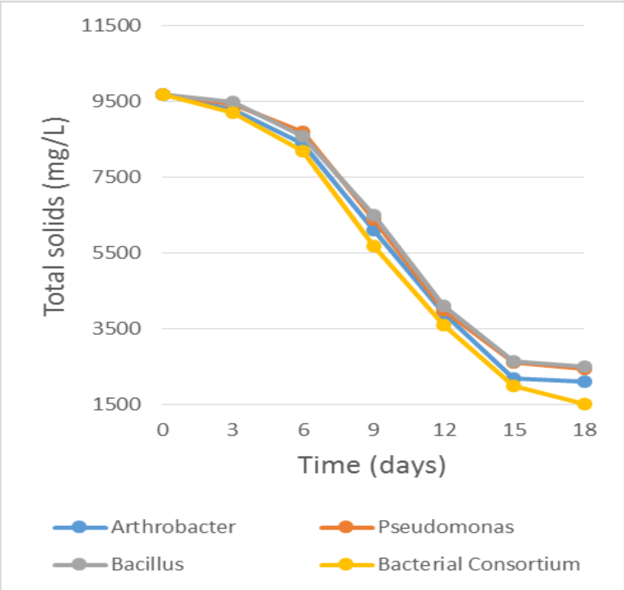

Figure 3: Comparison of total solids after treatment

3.1.3 Biochemical oxygen demand

BOD removal efficiency of Arthrobacter sp, Pseudomonas sp, Bacillus sp and bacterial consortium are 71.16%, 62.79%, 61.62% and 73.25% respectively. The reduction in BOD of rubber effluent after treatment is shown Figure 4.

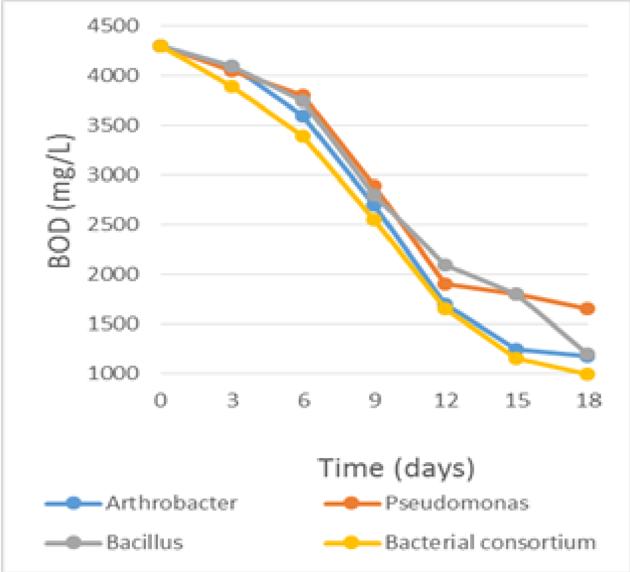

Figure 4: Comparison of BOD after treatment

The significant decrease in BOD values could be associated with consumption of organic material by microbes as a food source. The reduction in BOD can result in simultaneous reduction of coliform population. Though high growth of microbes had consumed the oxygen present in treatment unit, continuous and excess of aeration had provided to be an important reason for reduction in BOD.

Table 6: Characteristics of effluent after treatment using Arthrobacter sp.

Time (days)	*pH*	*Total Solids (mg/L)*	*BOD (mg/L)*	*COD (mg/L)*	*Ammonia (mg/L)*
0	4.5	9700	4300	7600	99
3	4.8	9300	4100	7100	72
6	5.9	8400	3600	6100	60
9	7.0	6100	2700	4500	39
12	7.8	3900	1700	2400	28
15	8.3	2200	1240	1670	21

Table 7: Characteristics of effluent after treatment using Bacillus sp.

Time (days)	*pH*	*Total Solids (mg/L)*	*BOD (mg/L)*	*COD (mg/L)*	*Ammonia (mg/L)*
0	4.5	9700	4300	7600	99
3	4.8	9500	4100	7300	75
6	5.7	8600	3750	6250	65
9	6.9	6500	2800	4800	46
12	7.7	4100	2100	2800	32
15	8.1	2650	1650	1950	29

Table 8: Characteristics of effluent after treatment using bacterial consortium

Time (days)	*pH*	*Total Solids (mg/L)*	*BOD (mg/L)*	*COD (mg/L)*	*Ammonia (mg/L)*
0	4.5	9700	4300	7600	99
3	4.9	9200	3900	7000	70
6	6.1	8200	3400	5900	58
9	7.4	5700	2550	4200	35
12	8.1	3600	1650	2350	27
15	8.5	2000	1150	1500	24

3.1.4 Chemical Oxygen Demand

COD reduction using Arthrobacter sp., Pseudomonas sp., Bacillus sp. and bacterial consortium were 78.02%, 76.34%, 74.34% and 80.26% respectively. The reduction in COD values might be due to more amounts of nutrients present in the form of dissolved and organic nature, which cultures could have used for growth. The comparison of reduction in COD after treatment is as shown in Figure 5.

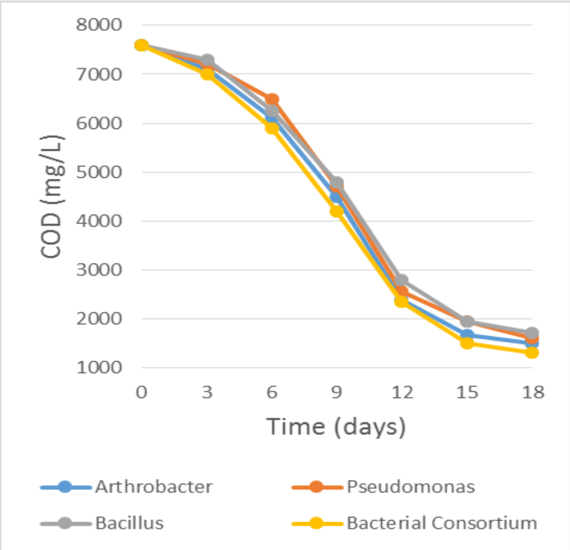

Figure 5: Comparison of COD after treatment

3.1.5 Ammonia

In comparison to initial levels, substantial reduction in ammonia was observed after treatment signifying the degradation of toxic solid components in the effluent by bacteria. Bacterial consortium showed the highest removal efficiency of 80% followed by Arthrobacter sp (78.78%), Pseudomonas sp (73.73%) and Bacillus sp (70.70%) respectively. Reduction in ammonia level indicates that bacteria degrade organic and inorganic constituents. The reduction in ammonia after treatment is as shown in Figure 6.

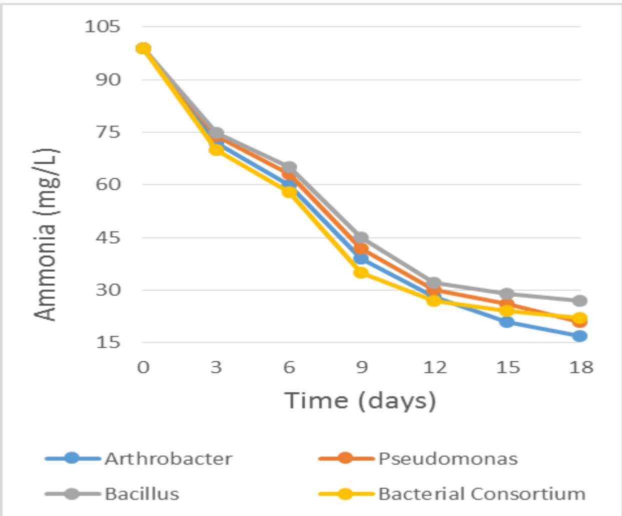

Figure 6: Comparison of ammonia after treatment

4. Conclusion

Any treatment system should be able to reduce or eliminate pollutant level in the effluent. In the present study, it was observed that the bioremediation of effluents with bacteria reduced physico-chemical characteristics significantly in a retention period of 15 days. Bacterial consortium was most effective in reduction of these factors and Bacillus sp was found to be least effective. Reduction in the physico-chemical properties of the effluent such as total solids (79.38%), BOD (73.25%), COD (80.26%), ammonia (80%) was observed after incubation with bacterial consortium. It is more economical and beneficial than a single culture. Further studies should be conducted to determine exact mechanism of bioremediation and reduction of waste quality parameters. This is necessary to improve the efficiency of wastewater treatment system.

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